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ABSTRACT

The paper focuses on one aspect of the training and utilization of military manpower--specialty training for first-term enlisted personnel. Costs of both formal and on-the-job training (OJT) are considered, as well as the returns from training for first-time enlisted personnel. After a description of the conceptual framework the paper describes the pilot test of the method, conducted among Air Force Aircraft Maintenance Specialists at Norton Air Force Base, California. Data consisted of performance measures of 64 trainees based on 12 supervisors' estimates, and background information on the trainees. Regression analysis of 13 variables concerning the relationship between OJT costs and the personal attribute data demonstrated that OJT costs are a function of the quality and quantity of prior education, prior civilian job experience, and ability. Regression analysis applied to alternative specifications of the model yielded similar results and further research studies were planned. The study concludes that fundamental changes in military manpower resulting from the all-volunteer force have increased the relative cost of training inexperienced personnel, and that this change may necessitate the military's seeking major increases in retention rates or adopting new training policies. Seven tables accompany the text. (JR)

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COST AND EFFICIENCY IN MILITARY SPECIALTY TRAINING*

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The training and utilization of military manpower is assuming increased importance in a period in which manpower costs are rising sharply. This paper focuses on one aspect of this issue--specialty training for first-term enlisted personnel--and deals briefly with the relationship between this topic and other aspects of the efficient management of military specialties. The conceptual framework, or methodology, for evaluating specialty training which has been developed at Rand considers the costs of both formal and on-the-job training as well as the returns to training for first-term enlisted personnel. This methodology was pilot-tested using members of one Air Force specialty, and results of that study are described here. In the pilot study, average costs and returns to training were estimated, and, in addition, estimates were made of the relationship between individual attributes and the cost of training.

Our approach, which is based on recent developments in labor economics, treats training as an investment. Training is an investment because it entails current costs and yields future returns. In this sense it is indistinguishable from expenditures on new capital equipment or R&D, which are more commonly recognized as investments. Within the Department of Defense investments in training are among the most sizeable investments each year. As Table 1 shows, the formal portion of training was estimated to cost over $6.0 billion in Fiscal Year 1973, and this does not include cost of on-the-job training (OJT). Moreover, these measured training costs have doubled since 1964.

Between 1964 and 1968, the major cause of increased training costs was the increasing size of military forces. However, from 1968 to 1973 training costs continued to rise in spite of declines in size of the force. The increases in these years are primarily the result of increases in military pay--especially first-term pay. At any point in time a sizeable proportion of the force is engaged in formal training, as can be seen from Table 2 which shows the projected distribution of student loads (man-years of formal training) for FY 1973 by type of training. About 75% of the student load is associated with new enlisted accessions. In total, training loads average over 10% of the active force. Moreover, since most ROTC graduates enter the active force on completion of their training, they should probably be included in the active force figures--in which case

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*This paper was presented to the Eighth Annual Department of Defense Cost Research Symposium at Airlie House, Warrenton, Virginia, November 7, 1973 (closed meeting).

Table 1

MILITARY TRAINING COSTS

	FY64	FY68	FY71	FY72	FY73
Training[a]	$2.25	3.90	4.36	4.54	4.55
Procurement[a] (Basic Training)	$ .78	1.53	1.52	1.65	1.81
Total Costs[a]	$3.03	5.43	5.88	6.19	6.36
Average Strength[b]	2,693	3,435	3,465	3,293	2,333
DoD Enlistments and Inductions[b]	495.9	852.6	552.3	423.7	445.8

[a]Costs in Billions of Dollars

[b]Manpower in Thousands

SOURCE: DoD Military Manpower Requirements Report for FY-1973

Table 2

RECOMMENDED STUDENT LOADS* FOR FY 1974

Type of Training	Regular Forces	Reserve and National Guard	Total
Recruit	89,200	30,600	119,800
Specialized	107,600	17,000	124,600
Professional	29,000	2,600	31,600
Flight	10,000	1,000	11,000
Officer Acquisition	12,600	78,100	90,700
Total	248,400	129,300	377,700

*Student Man-Years or Average Student Level During the Year

SOURCE: DoD Military Manpower Training Report for FY 1974

student loads make up approximately 15% of the force. In addition, the staffs of military schools are largely drawn from the active force.

With the large increase in the cost of manpower, particularly first-term personnel, and with stringent budgets for DoD, training costs are becoming a more important element in the defense budget. Consequently, Congress has taken an active interest in the subject of training costs. Beginning in fiscal 1974 it levied a requirement that DoD justify the services' training loads with a yearly report on training requirements, and recent legislation gave Congress the authority to set an annual level for military training loads. Consequently, in the future no military training can take place without prior Congressional approval. Clearly the services' training practices are going to be under much closer scrutiny in the future than they have been in the past.

To many outside observers, it appears that military training is both excessive and inefficient. Military training practices appear questionable because they differ so sharply from those of civilian employers in the U.S., both private and public. However, this should not really be surprising since the military differs from other employers in a number of important respects. The military requires a large number of specialists and there is a high rate of turnover in the force. Recruits typically have good general abilities but little applicable training and experience, partly because many of the skills required are not common in the civilian sector. Moreover, since the military has a unique capability to enforce labor contracts it can expect that nearly all trainees will remain for the full term of enlistment. Thus, it is in a position to guarantee returns on its investment in training for a period of three or four years, which civilian employers are not.

The major source of difficulty in justifying training policies is difficulty in identifying the full costs of and returns to military training. Under the present accounting system where only the costs of school training are specific, identifiable budget items, it may appear that an arbitrary reduction of formal training loads leads to a real cost saving. In fact, a reduction in formal specialized training may increase the total cost of training since the cost of training which occurs outside the context of the military school may increase by more than the savings in school costs. It may also affect the benefits, or returns, to the military from trained personnel. There are fundamental problems in providing a justification of military training practices without some evidence on these other costs and returns and since only formal training costs have been identified, the tendency exists for outside observers to believe that efficiency would be improved if formal training were reduced.

Our approach to the examination of first-term specialty training explicitly includes the returns and all the costs of military training. The estimation of heretofore unmeasured costs and returns is a crucial element in justifying military training practices to Congress and to outside agencies like OMB. Our interest in training is, however, somewhat broader than this. If the total costs and returns of military training are unknown, we do not know how efficient or how justifiable military manpower practices are. Perhaps the critics of military training are correct, but it may also be true that formal military training is not sufficiently thorough or intensive and that more formal training is needed rather than less. Moreover, the full costs of and returns to training are relevant with respect to a broad range of military policies ranging from retention and lateral entry to the efficient labor intensity in military activities.

II. A CONCEPTUAL FRAMEWORK

There are two principal questions, or at least two versions of the same question which we believe must be asked in determining the efficiency of military training practices. How much specialty training is justified for first-term personnel? And, what is the best mix between formal specialty training and the learning or training which occurs on the job? This paper does not provide answers to these difficult questions, and even if some answers could be provided they would not represent general solutions. The answers are probably different for each military specialty, because specialties differ according to the type of tasks which must be performed and the degree of proficiency necessary for effective performance. The paper does provide a conceptual framework which can be used to clarify the principal issues in the attainment of efficient military training practices.

TRAINING AS AN INVESTMENT

The framework used here treats training as an investment, and, as with other investments, it is useful to identify two flows which measure investment costs and returns. In a private firm, these flows are labeled expenditures (E_t) and receipts (R_t) and can be written as

$$E_0, E_1, \ldots, E_{n-1}$$

and

$$R_0, R_1, \ldots, R_{n-1},$$

for the n time periods. Discounting by the market interest rate (i), we can compute the present values of the flows of expenditures and receipts:

$$E_0 + \frac{E_1}{1+i} + \frac{E_2}{(1+i)^2} + \ldots + \frac{E_{n-1}}{(1+i)^{n-1}} = \sum_{t=0}^{n-1} \frac{E_t}{(1+i)^t} \qquad (1)$$

and

$$R_0 + \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \ldots + \frac{R_{n-1}}{(1+i)^{n-1}} = \sum_{t=0}^{n-1} \frac{R_t}{(1+i)^t} \qquad (2)$$

If the present value of receipts is greater than the present value of expenditures, the difference in present values is the *net return* on the investment. If expenditures exceed receipts, the difference is the *net investment* at the end of n periods. A firm will undertake an investment if the present value of expenditures is less than or equal to the present value of receipts over the entire life of the investment.

Training Costs and Returns

The same type of formulation applies to military training. Expenditures include the cost of pay and allowances, accession costs, and the direct outlays on formal specialty training. Accession costs include recruiting costs, travel costs, and the cost of basic military training.* Direct outlays on formal specialized training include instructors, materials, equipment, and other variable costs associated with formal training. The benefit the military derives from training is the value of the labor services provided by the individual in each period.

The costs of and returns to first-term training are represented graphically in Figure 1, where, for simplicity of exposition, accession and formal training costs are combined. As the figure suggests, these costs can be thought of as consisting of two components: the pay and allowances of trainees (the area above the horizontal axis), and direct outlays (the area below the horizontal axis). These are the components of training costs for which measures currently exist. In addition, however, first-term training involves OJT which is costly to the military. The costs of OJT can be measured by comparing the individual's productivity over time with his pay and allowances over time. During the time when the value of his contribution to military effectiveness is less than his pay and allowances, the military is incurring costs for on-the-job training.

In most specialties it is doubtful that first-term personnel begin producing positive net returns as soon as formal training ends. Specialty schooling is, therefore, only one component of individual training. The trainee normally acquires additional skills and experiences an increase in proficiency after he arrives at the unit. During this period, he will also receive added instruction, either from a supervisor or from more experienced co-workers. This entire process, whether part of an organized program or not, represents a real and costly part of individual military training. In Fig. 1, productivity is initially negative, indicating that supervisory costs outweight the individual's direct contribution to his unit. Since we are dealing with an individual who has attended tech school, the rate of increase in his value to the unit should be more rapid than, for instance, the rate of increase for an individual whose training occurs exclusively on the job. When productivity is equal to pay and allowances, the military begins to earn a return on its investment in training.

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*To avoid double counting the cost of BMT is defined here to exclude pay and allowances of recruits.

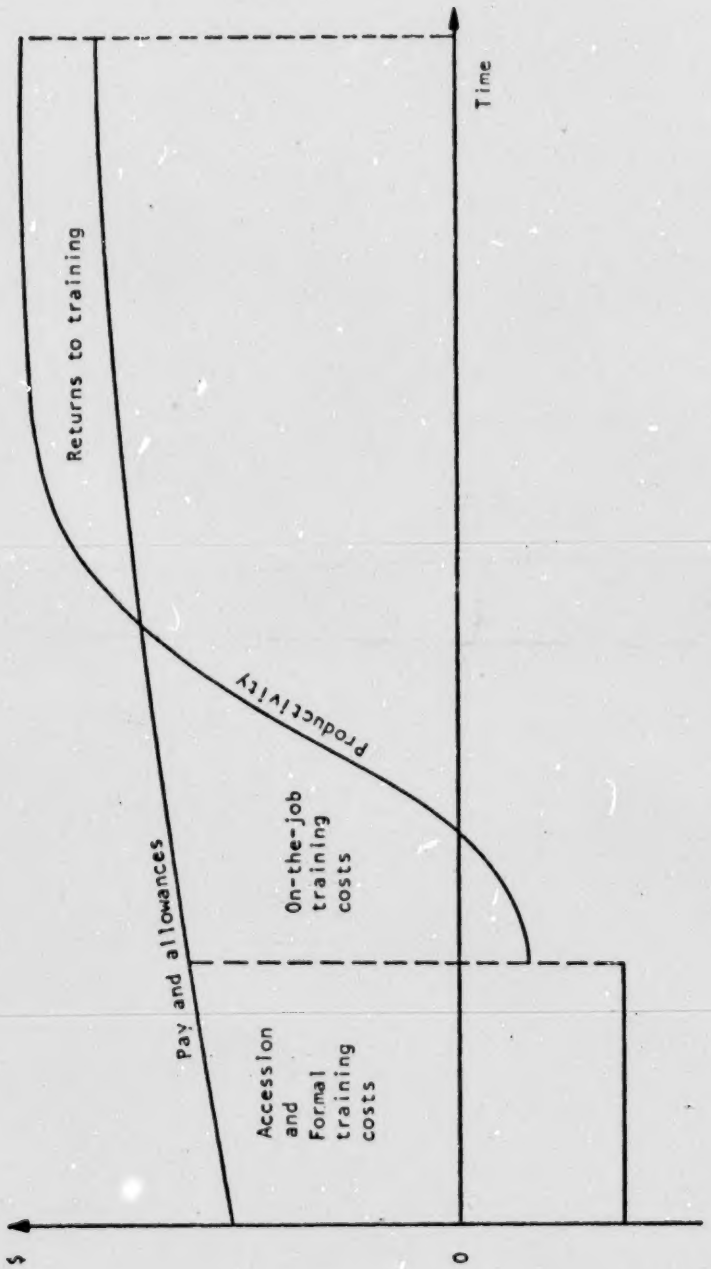

Fig. 1--Cost and returns to military training in the first term of service

These relationships can be represented mathematically in a formulation similar to that for other investments. In the following formulation we make the simplifying assumption that all accession costs and training outlays are incurred in the first period.* The magnitude of these costs is assumed to be k dollars. The stream of expenditures on personnel for n periods in the first term of service is

$$W_0 + k,\ W_1,\ W_2,\ \ldots,\ W_{n-1}\ ,$$

where W_t represents pay and allowances in period t. The benefit the military derives from training is the value of the individual's net contribution to military capability. It is an incremental contribution which reflects the change in military product due to the presence of one individual in the military. For these reasons economists refer to this net contribution as the value of the marginal product (VMP) of the individual. This stream of benefits, or returns, is written:

$$VMP_0,\ VMP_1,\ \ldots,\ VMP_{n-1}$$

Since in this hypothetical case we assume that the individual is in formal training during the entire first period, VMP_0 is equal to zero.

As in the case of private investments, investment costs and returns in the military should be discounted by the appropriate rate of interest. The present value of expenditures is

$$W_0 + k + \sum_{t=1}^{n-1} \frac{W_t}{(1+i)^t}\ ,$$

and the present value of benefits is

$$\sum_{t=1}^{n-1} \frac{VMP_t}{(1+i)^t}\ .$$

The difference between the present values of the two streams represents the net return (or net investment) on training for first-term personnel.

Algebraically, formal training costs (including accession costs) are

$$F = W_0 + k. \qquad (3)$$

*The model can also be broadened to include attrition, but this would serve no useful purpose here.

Assuming that VMP is less than W for the first j periods, the cost of training on the job (J) can be written:

$$J = \sum_{t=1}^{j} \frac{W_t - VMP_t}{(1+i)^t} \tag{4}$$

For the remainder of the first term the military earns a positive return. The value of this return (Q) is also equal to the discounted value of the difference between VMP and W. In this case,

$$Q = \sum_{t=j+1}^{n-1} \frac{VMP_t - W_t}{(1+i)^t} . \tag{5}$$

The net return on military training (N) is the difference between the present values of the benefits stream and the expenditures:

$$N = \sum_{t=1}^{n-1} \frac{VMP_t}{(1+i)^t} - \left[W_0 + k \sum_{t=1}^{n-1} \frac{W_t}{(1+i)^t} \right] \tag{6}$$

Rearranging terms yields

$$N = \sum_{t=1}^{n-1} \frac{VMP_t - W_t}{(1+i)^t} - (W_0 + k), \tag{7}$$

where the first term represents the difference between gross returns and the costs of training on the job and the second term is formal accession and formal training costs. Hence, the net return on the investment in military training is equal to the gross return minus the cost of formal and on-the-job training:

$$N = \sum_{t=j+1}^{n-1} \frac{VMP_t - W_t}{(1+i)^t} - \sum_{t=1}^{j} \frac{W_t - VMP_t}{(1+i)^t} - (W_0 + k) \tag{8}$$

$$= Q - J - F$$

Criticism of the Costing Methodology

This general approach to the subject of military training is open to two criticisms. The first is that attributing improvement in proficiency on the job to training confounds training with experience. In our view there is no benefit to making a distinction between the gains in proficiency due to formal instruction and the gains due to experience, since learning is a product of both instruction and experience. Experience is a particular form of training, one in which there are no inputs of instruction or supervision. In many cases the combination of instruction and experience would be a more effective

way of training than pure experience. This will be true if the costs of the instruction are less than the value of the increased trainee proficiency.

The second possible objection to our approach is a more basic one. It can be argued that military training, particularly training on the job, is costless in peacetime. In order to be prepared to meet wartime demands, military units often carry many more men than are required to conduct peacetime operations. Therefore, it is argued, it does not cost anything to devote manpower to on-the-job training. If they were neither supervising training nor being trained, the men would have little else to do--in fact, OJT may even be beneficial since it keeps the troops occupied. The argument rings true because it is--as far as it goes. Very little is lost in the way of peacetime productivity because of training which occurs on the job. The error is in valuing the military in terms of its peacetime productivity. The cost of conducting training during peacetime is not that peacetime productivity is reduced, but that maximum potential output is reduced. The peacetime military is like an inventory which is being held in case a war breaks out. If the force contains a high proportion of individuals who are not fully proficient at their jobs, then its potential wartime productivity is reduced. The problem is even more severe when surge capability, which requires a backlog of experienced personnel, is taken into account. Thus, there is less deterrent value from an inexperienced military force.

The Concept of Efficiency

Efficiency in military training can be defined as the set of training practices which maximizes the net return to training.* For instance, longer and more extensive formal training should tend to reduce the cost of training on the job, and if OJT costs occur for a shorter period of time, the gross returns to training should increase. The optimal length of formal training in a specialty--that is, the training length which maximizes the net return--occurs where the cost of an additional increment to formal training is just offset by the gains through increased gross returns and reduced OJT costs. In equilibrium, the net return from an efficient training policy will be zero because at the margin the discounted cost of training should just equal the discounted returns. In practice, however, efficient training policies can occur in association with either positive or negative net returns. If the net return is negative, for instance, then some other aspect of military policy may not be optimal. For example, it may be that retention rates are too low in the specialty, resulting

*The definition of net return should be broadened to include the returns from personnel who stay beyond the first term of service.

in small total returns to training beyond the first term. Or too many factors of production may be currently employed in the specialty causing the value of the marginal product of an additional unit of labor to be very low relative to military pay. Conversely, when a negative return on military training is observed, it does not necessarily mean that training policies are inefficient. In fact, any of a wide range of military policies could be contributing to this, and a more comprehensive model is needed to analyze the situation and recommend policy changes. A brief discussion of such a model is given in the concluding section of this paper. That discussion includes a few examples of how compensation, retention, and training policies interact in determining overall efficiency in manning military specialties.

MEASUREMENT OF TRAINING COSTS AND RETURNS

Data are generally available for estimating accessions cost and the costs of formal training, but our approach to training costs and returns requires that estimates also be made of the cost of on-the-job training and the returns to training. Attempts to measure military OJT costs are relatively recent, and there is not yet a widely accepted costing methodology or a broad-ranging set of OJT cost estimates. In addition to a recently completed Rand study*, three major studies of OJT costs have been completed. Arzigian (Navy Personnel Research Laboratory) made rough estimates of these costs for four broad groups of Navy occupations; Weiher and Horowitz (Center for Naval Analyses) estimated the costs of on-the-job training for 39 Navy ratings; and Dunham (Air Force Human Resources Laboratory) analyzed the costs of training communications specialists to the apprentice skill level.** Furthermore, the Air Force is funding an extension of Dunham's work.

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*See Robert M. Gay, *Estimating the Cost of On-The-Job Training in Military Occupations: A Methodology and Pilot Study*, The Rand Corporation, R-1351-ARPA (Forthcoming).

**See Simon Arzigian, *On-The-Job Training Costs: An Analysis*, Navy Bureau of Naval Personnel, WRM 67-52, Washington, D.C., June 1967; Rodney Weiher and Stanley A. Horowitz, *Formal and On-The-Job Training for Navy Enlisted Occupations*, Institute of Naval Studies, Report No. 173-71.10, November 1971; Alan D. Dunham, *Estimated Cost of On-The-Job Training to the Three-Skill Level in the Communications Center Operations Specialty*, Air Force Human Resources Laboratory, Lackland Air Force Base, Texas, June 1972.

The approach developed and pilot tested at Rand is different from those used in the other studies cited in two important respects. First, training costs are estimated for specific individuals rather than for the "typical trainee." One advantage of making individual estimates is that the relationship between personal attributes of the trainees and estimated training costs can be explored. The results of this analysis for the pilot study data are presented in the following section. Second, the method of cost estimation is basically different. Rather than estimating and valuing trainer and trainee hours devoted to OJT, we have compared the trainee's net contribution to his unit over time with his cost to the military over time, as illustrated in Fig. 1. A supervisor's responses to a survey questionnaire were used to estimate the productivity (contribution to military capability) of the trainee from the time he joined the operational unit until he completed his first tour of duty. A comparison of VMP with the cost of pay and allowances is made to estimate the cost of training on the job and the gross returns to military training.

Estimating the VMP

The principal problems in implementing this approach are concerned with the definition and measurement of the value of the marginal product of the individual. In general, VMP is defined as the increase in physical output attributable to the addition of an individual to the unit multiplied by the price per unit of output. Physical productivity is very difficult to measure in the military since most military activity results in the production of services rather than tangible goods. Moreover, once physical productivity is defined, there is a further problem of defining an acceptable set of prices for military outputs. Our solution to these very difficult problems has been to develop an indirect method of measuring VMP. The first step is to estimate the *relative* productivity of the enlisted man from the time he leaves training school to the end of the first term of service. His productivity is defined relative to the productivity of the fully-trained journeyman. To approximate this curve, we have identified two of the more easily defined points on it: the time when the individual achieves a positive value for the unit and the time when the individual becomes fully proficient. These estimates are discussed in more detail in the presentation of the results of Rand's pilot study.

To get a monetary value for the marginal product, we set the VMP of the fully-trained journeyman at the pay and allowances (including reenlistment bonuses) of second-term military personnel. The fully proficient first termer is assumed to be equal in productivity to the average (journeyman level) specialist beginning the

second term of service. Since the military makes a voluntary decision to retain second-term personnel, we assume that the average value of individuals in the specialty is as great as the cost of pay and allowances for second termers. Using estimates of relative productivity over time, we can apply this implicit price of military output to find the value of personnel who are less than fully trained.

This method of estimating VMP is easiest to understand where direct substitutions may be made between inexperienced and experienced personnel within a given military structure. In these cases inexperienced and experienced personnel differ in terms of proficiency and not in terms of the types of tasks performed. If the relative productivity index indicates inexperienced individuals are one-half as productive as experienced personnel, then one fully-trained enlisted man can take the place of two inexperienced enlisted men. The value of the marginal product of inexperienced personnel is one-half the VMP of experienced personnel.

The rationale for placing a value on VMP does not, however, depend upon the ability to make specific substitutions between experienced and inexperienced labor. If there is an efficient allocation of resources within the military, the output of a particular military activity, such as aircraft maintenance, will be increased to the point where cost of an additional unit of output is equal to the value of its contribution to national defense. A condition for efficiency is to employ additional factors of production until the value of the last unit's output of each factor is equal to its cost. Since the cost of fully-trained personnel can be approximated by the level of second-term pay and allowances, the VMP of fully-trained personnel can be approximated by this cost. Furthermore, since we know the relative productivities of fully trained and inexperienced personnel, the value of the output of inexperienced personnel can also be calculated. This rationale does not require that experienced and inexperienced personnel perform similar tasks within the unit, and can be used to value the marginal product of entirely different factors of production. The same conditions would apply to each pair of factors of production. The assumption that efficient allocation of resources occurs in the military does place some restrictions on this method of estimating VMP. Nevertheless, economic analysis has been able to yield many useful insights into one part of an economic system by treating the rest of the system as though it were in equilibrium.

Marginal Cost of Second-Term Personnel

Finally, the use of second-term pay and allowances to estimate the VMP of fully-trained personnel may result in a conservative es-

timate of the value of fully-trained personnel. The military has no incentive to retain first-term personnel unless the VMP is greater than or equal to the marginal cost of retaining additional personnel. The marginal cost exceeds the wage rate because an increase in second-term pay is usually necessary to obtain increased retention. Pay increases are paid to all reenlistees, including those who would have reenlisted at the original pay level; therefore, the marginal cost of additional retention must include the extra pay which goes to men who would reenlist at the original pay level. A mechanism exists in the military to provide increased second-term pay in order to obtain an increase in reenlistments. Two special pay programs--the variable reenlistment bonus and proficiency pay (specialty)--have been established to increase reenlistments in designated specialties.

The marginal cost of second-term personnel depends on the supply response to higher levels of military pay--that is, the increase in military pay necessary to obtain a given increase in reenlistments. Supply response is usually measured by the supply elasticity of reenlistments, which can be roughly defined as the percentage increase in reenlistments occuring as a result of a one percent increase in military pay. The marginal cost is equal to

$$W' \left(1 + \frac{1}{\varepsilon}\right)$$

where W' is the level of second-term pay and allowances and ε is the supply elasticity. Table 3 shows the relationship between pay elasticity and the marginal cost of reenlistees for a range of pay elasticity values. As that table shows, in the extreme case where the supply elasticity is infinite, the marginal cost is equal simply to W'. In this case, the military can obtain unlimited reenlistments at the prevailing pay level. Studies of first-term reenlistments, such as those performed for the President's Commission on an All-Volunteer Force, have, in fact, found reenlistments to be highly responsive to military pay. These studies found elasticities of supply between 2.0 and 3.0 for the Army, Navy and Air Force. An elasticity of 2.5 implies the marginal cost of a reenlistment is equal to 1.4 times the wage rate.

The pilot study made the conservative assumption that the VMP of fully-trained personnel is equal to the pay level W' rather than the marginal cost. The results of this study which are reported in the following section, may underestimate the net return to military training in aircraft maintenance. However, the principal focus of the following section is on the cost of on-the-job-training. These costs proved to be insensitive to the variations in the VMP

of fully-trained personnel; consequently, the results reported are not affected by this assumption.

TABLE 3

RELATIONSHIP BETWEEN PAY ELASTICITY
AND MARGINAL COST OF REENLISTEES

Pay Elasticity (ε)	Marginal Costs Of Reenlistees
0	∞
0.5	3.0 W'
1.0	2.0 W'
1.5	1.7 W'
2.0	1.5 W'
2.5	1.4 W'
3.0	1.3 W'
5.0	1.2 W'
10.0	1.1 W'
∞	W'

III. PILOT STUDY

The feasibility of the method of estimation just described was tested in a pilot study conducted at Norton Air Force Base, California.* The pilot study focused on Aircraft Maintenance Specialists (AFSC 431x1). This is the largest Air Force specialty, and is resonably representative of Air Force maintenance specialties in terms of overall technical difficulty. Data for our pilot study consisted of the performance measures for individual trainees mentioned previously and background information on these trainees (obtained from Air Force personnel files and the Air Training Command). Regression analysis of the relationship between estimated OJT costs and the personal attribute data provided a basis for assessing the importance of these personal attributes as influences on OJT costs. The results of the pilot study are reported here in some detail both because they lend support to the estimation procedure just described and because they are interesting in their own right. However, the sample for the pilot study was small (the results reported here are based on 12 supervisors' estimates of the performance of 64 trainees), and a very simple estimation procedure was used in it. Therefore, the results reported here should be viewed as first approximations rather than definitive answers.

In the pilot study, the individual's productivity was approximated using a survey questionnaire in which the trainee's supervisor was asked to estimate how long it took the trainee, after he reached the job, to achieve two major milestones. The first, point 1 in Fig. 2, is the time when the trainee achieved zero net productivity. That is, the point when his value to the unit was approximately equal to the productivity lost by others in the unit who supervised his work. The second, point 2, is the time when the individual achieved journeyman proficiency. As previously noted, the value assigned to a fully-trained journeyman represented here by the height at point 3) is taken to be the wage rate received at the beginning of the second tour of duty. Together, points 2 and 3 identify point 4 on the productivity curve, which is the trainee's value to the military when he first achieved journeyman status.

Using this information, a rough approximation of productivity over time can be made as shown in Fig. 3. We assume that an individual's productivity increases at a constant rate from the time he joins the unit and begins his on-the-job training until he becomes a fully-trained journeyman, and that after achieving journeyman status, his productivity remains constant throughout his first term of duty.

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*A more complete description of this research is contained in Robert M. Gay, *op. cit.*

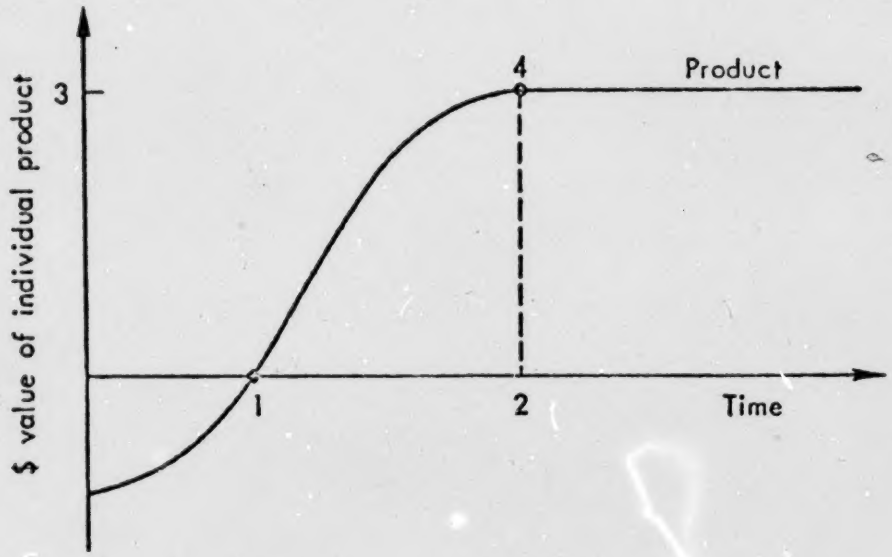

Fig. 2—Trainee productivity over time

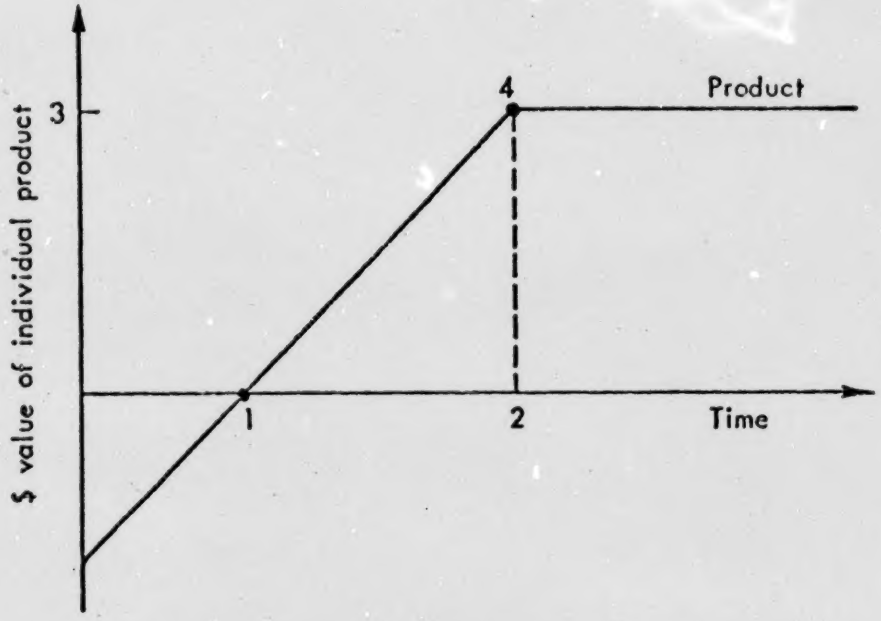

Fig. 3 — Estimated productivity over time

Although crude, this still seems to offer a reasonable approximation of the individual's productivity as perceived by his supervisor.

As indicated earlier, the costs of OJT can be estimated by comparing pay and estimated productivity over time. For the individuals in our pilot study, the average estimated cost of OJT was approximately $6,600, and the average estimated first-term return to training was approximately $3,400. OJT costs do not, however, constitute the total investment in training for members of this specialty. The estimated average total cost of first-term training for Aircraft Maintenance Specialists is shown in Table 4. Each recruit attends an Air Force tech school which lasts 12 weeks and costs about $3,200, and in addition there are accession costs (including basic training costs) of about $1,400 and the cost of a PCS move to the first duty station.

Table 4

AVERAGE TOTAL COST OF FIRST-TERM TRAINING

Type of Cost	
Accession cost	$ 1,414
Technical school training	3,161
Travel to duty station	599
On-the-job training	6,600
Total first-term training cost	$11,774

The estimated total investment of almost $12,000 per man is a surprisingly large figure in view of the fact that this is not an especially technical Air Force specialty. On the other hand, we estimate returns to training of over $3,400 in the first term, and for those who reenlist, there are no doubt additional returns to the military in subsequent periods although we have not attempted to quantify them. It is worth noting here that OJT costs constitute over half the estimated first-term training costs in this specialty. Since these costs have been largely unquantified in the past, it is likely that the full cost of military labor turnover has not been recognized in making decisions regarding force structure and the like. Total training costs can be reduced in a number of ways--for example by increasing retention of trained personnel, improving opportunities for lateral entry of trained civilians, utilizing trained personnel more effectively. However, policies which reduce training costs

invariably carry costs of their own and their desirability depends in part on the magnitude of total training costs.* One implication of both our research and the similar studies previously cited is that the magnitude of total training costs warrants considerable attention to alternatives which might be effective in reducing it.

PERSONAL ATTRIBUTES AND THE COST OF OJT

Our approach to cost estimation provides a unique opportunity to relate training costs to the attributes of trainees. This sort of information has great potential value as an aid in deciding on quality standards for accession and for assignment to specific specialties, the type of training to give a particular recruit, and the like. The results presented here are indicative of the type of findings which can be expected from such analyses, although for reasons mentioned earlier their direct policy implications are quite limited.

Definition of Variables

To estimate the relationship between training costs and personal attributes, cost estimates for the individuals in our sample were merged with background data on these individuals obtained from base personnel files. Included were measures of ability, civilian job experience, and the quantity and quality of education, as well as other variables frequently thought to be related to productivity. The personnel records include three potentially relevant measures of ability. The Armed Forces Qualifying Test (AFQT) and the General Aptitude Index of the Airman's Qualifying Examination (AQE1) are measures of general intelligence; the Mechanical Aptitude Index of the Airman's Qualifying Examination (AQE4) is a measure of aptitude in those areas deemed most relevant to performance of the job duties in this specialty. Education is measured in years of formal schooling (YRSED), and as a proxy for years of civilian job experience we have defined the variable:

$$EXP = AGE - YRSED - 5.$$

This variable does not, of course, measure actual civilian job experience, although as a measure of the number of years when full-time

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*In this regard, it should be noted that the first-term pay increases associated with movement to an all-volunteer force have substantially increased first-term training costs and are one reason for the current high interest in first-term training.

civilian employment could have occurred, it is presumed to be positively correlated with civilian job experience.

Dummy variables for race (WHITE = 1 if the trainee is Caucasian) and region of origin (SOUTH = 1 if the trainee's hometown is in the census South) are included as measures of the quality of prior education. A continuous variable for size of hometown (CITY = population in thousands) is included because both quality of formal education and mechanical aptitude score are thought to be influenced by the size of hometown. Also included are measures of marital status (WED = 1 if married) and dependency status (DEPS = 1 if more than one dependent), on the basis that individuals who are married and/or have dependents may differ in their motivation from other personnel. Table 5 shows the mean values and standard deviations of these variables.*

Table 5

MEAN VALUES AND STANDARD DEVIATIONS OF REGRESSION VARIABLES

Variable	Designation in Regression Equations	Mean	Standard Deviation
Cost of training (dollars)	COST	6,599	3,413
General aptitude	AFQT	51.16	20.67
	AQE1	54.92	18.38
Mechanical aptitude	AQE4	61.56	12.21
Prior education (years)	YRSED	11.56	.98
Civilian job experience (years)	EXP	3.44	1.34
Region of origin	SOUTH	.23	**
Race	WHITE	.78	**
Size of hometown (thousands)	CITY	425.12	1163.1
Marital status	WED	.19	.39
Dependency status	DEPS	.08	.98
Average tech school performance score	TSP	89.62	5.23
Average tech school written score	TSW	81.46	7.32
Tech school course score	TSF	85.05	5.87

*The last three variables in Table 5 are measures of performance in technical school and are described in conjunction with the description of results of analyses in which they were included.

**The standard deviation of a dichotomous variable is given by the expression f(1-f), where f represents the fraction of cases having the requisite characteristic.

Respondent Influences on Estimated Training Costs

In any regression analysis there is a certain amount of random variation or "noise" attributable to factors which are not included in the model. Although this noise tends to mask the real effects which are of interest, it is unavoidable since it is never possible to allow for all possible factors influencing the dependent variable. In analysis based on survey data, however, differences among respondents in their definitions of terms and interpretation of questions add a *systematic* component which further masks the relationships being estimated. Differences in mean values and standard deviations of cost estimates among respondents in our sample were quite pronounced, suggesting that the systematic component was large in our data. One source of differences in estimated costs is presumably differences in trainees' personal attributes; but it appeared that our observed differences in the mean and variance of estimates among respondents were not solely attributable to differences in the characteristics of the members of the respondents' groups of trainees. To eliminate the effect of factors unique to particular respondents we have employed an iterative procedure developed at Rand which uses least squares regression analysis to produce coefficient estimators which are asymptotically equivalent to maximum likelihood estimators.* Essentially, the procedure is a generalization of the standard dummy variable technique. It adjusts for that portion of differences in both the average level and the variance of respondents' estimates which is not attributable to their trainees' characteristics.

Analysis of Personal Attribute Relationships

Our basic specification of the relationship between OJT costs and trainee attributes is that OJT costs are a function of the quantity and quality of prior education, prior civilian job experience, and ability. The estimated relationships, using AQE4 as the ability measure, are:

$$\begin{aligned} \text{COST} = 16{,}291 &- \underset{(-2.69)}{669.86} \cdot \text{YRSED} - \underset{(-.375)}{173.76} \cdot \text{SOUTH} \\ &+ \underset{(1.494)}{733.57} \cdot \text{WHITE} - \underset{(-.055)}{9.99} \cdot \text{EXP} - \underset{(2.440)}{39.74} \cdot \text{AQE4}, \end{aligned} \tag{9}$$

$R^2 = 0.274$ (t ratios are in parentheses).**

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*The adjustment technique and its properties are described in Appendix F of Robert M. Gay, op. cit.

**Because of the adjustment procedure used here, the coefficient of determination should be interpreted as indicating that portion of the variance in COST which is not attributable to respondent influences and which is explained by variables in the regression equation. A similar interpretation applies to the t ratios.

As anticipated, the quantity of education and measured mechanical aptitude were both significantly related to estimated OJT costs. The estimated coefficients were significantly different from zero at the 1 percent and 5 percent levels respectively, and the strength of these relationships is somewhat surprising in view of the limited variation of these measures. Moreover, the magnitudes of these effects are substantial. An additional year of education is associated with a reduction of over 10 percent in the level of COST, measured at the mean, and an additional ten points of measured mechanical aptitude is associated with a reduction of approximately $400, or about 6 percent.

The magnitudes of these effects indicate that there is a real possibility that total training costs could be reduced by considering the results of such analyses from a number of specialties in making specialty assignment decisions. Within this occupation, our estimated coefficients indicate possible tradeoffs between education and ability. Since an additional year of education is estimated to have about the same effect on estimated training costs as an additional 17 points on the mechanical aptitude test, obvious opportunities exist for developing selection criteria which define minimum combinations of education and ability in which reductions in the current minimum AQE score are made for those with more than the average amount of education.

The results with respect to the civilian job experience variable were somewhat surprising, especially since a similarly defined variable was significant in studies of the determinants of civilian earnings. The lack of significance of the region variable was also somewhat surprising since similar variables have been shown to be significantly related to earnings. It is generally assumed that being from the South adversely affects productivity because it adversely affects the quantity and quality of schooling. However, our results show that being from the South has no statistically significant effect on military productivity in this specialty.

The race effect, while not statistically significant by conventional standards, is much stronger than either the experience or region effects, and since it is significantly different from zero at the 15 percent level in our sample (using a two-tailed test), it would not be surprising to see this effect become statistically significant in a larger sample. Civilian earnings studies have invariably found the earnings of whites to be greater than those for similar nonwhites, while our coefficient indicates that whites are substantially more costly to train (i.e., less productive) than nonwhites. The differences in civilian earnings may be at least partially attributable to discrimination in civilian labor markets, but studies which have attempted to identify the portion of earning differences attributable to discrimination have uniformly found this to be less than 100 percent. Therefore, this result would be quite important if found to be significant in subsequent, larger samples.

Our pilot study data did not permit us to explore alternative explanations for this race effect. However, at least three hypotheses should be considered if this result is found in future research. First, it could be due to bias in the supervisors' ratings. That is, it could be that in order to avoid the appearance of discrimination the supervisors in our sample rated nonwhites more favorably than similar whites. Second, it could be due to cultural bias in the ability test. It is well-known that nonwhites' scores on such tests tend to be substantially lower than those for similar whites. If the difference in scores reflects a cultural bias in the test rather than a differential ability to perform on the job, it would mean that the ability measure is failing to control adequately for the ability of nonwhites and that this effect is showing up in the race coefficient. Third, it may be that nonwhites' on-the-job performance is better than that of similar whites because they are more highly motivated to learn military occupations. The evidence of civilian labor market discrimination is abundant, and it is not unreasonable to assume that this influences the performance of the nonwhites in military occupations. Since there is less discrimination in the military, nonwhites are more likely than whites to view the military as an occupational choice and therefore to be more highly motivitated to learn military occupational skills. Exploration of such alternative hypotheses is one way in which further research in this area may yield important new insights.

Alternative Model Specifications. Table 6 contains regression relationships obtained under alternative specifications of the model. The results under these alternative specifications are described briefly in the remainder of this section.

In Table 6, Eq. (9) is repeated for comparison with alternative specifications of the model. Equations (10) and (11) differ from Eq. (9) in that measures of general ability are used rather than mechanical ability. Our data base provides an opportunity not generally available in studies on civilian earnings to explore the issue of whether the more general measures of ability perform as well as a measure more closely related to job duties.

As these results indicate, changing the measure of intelligence does not drastically alter the implications which are to be drawn from the data. However, mechanical aptitude does appear to be more closely related to OJT costs than either general intelligence measure. Both the proportion of variance explained by the included variables and the significance level of the ability measure are greatest when ability is measured by mechanical aptitude test scores. To some extent this supports current Air Force policy of using AQE4 score as an assignment criterion, although, as was previously noted, our results indicate that prior schooling should also be considered in assigning recruits to this specialty. The estimated coefficients are also not altered substantially when the race and region variables are

Table 6

ESTIMATED RELATIONSHIPS BETWEEN PERSONAL ATTRIBUTES AND TRAINING COSTS

Equation No.	Variable (t ratio)										
	YRSED	SOUTH	WHITE	EXP	AQE4	AQE1	AFQT	WED	DEPS	CITY	R^2
(9)	-669.86 (-2.697)	-173.76 (-.375)	733.57 (1.494)	-9.99 (-.055)	-39.74 (-2.440)						.274
(10)	-822.82 (-3.129)	-121.05 (-.247)	749.60 (1.452)	-150.92 (-.777)		-21.20 (-1.719)					.235
(11)	-667.33 (-2.396)	-353.26 (-.689)	1,149.8 (1.965)	-105.23 (-.514)			-28.41 (-2.177)				.237
(12)	-704.08 (-2.859)			-6.56 (.036)	-34.08 (-2.172)						.248
(13)	-737.63 (-2.810)	-192.61 (-.396)	674.10 (1.304)	74.42 (.374)	-39.21 (-2.251)			-551.04 (-.800)	-712.12 (-.727)	.01 (.588)	.318

omitted (Eq. (12)) or when additional controls for marital and dependency status and size of hometown are added (Eq. (13)). These added variables had no significant relationship with estimated training costs.

Tech School Achievement and OJT Costs. All new accessions who are assigned to become Aircraft Maintenance Specialists attend a 12-week technical school before being sent to a base to begin OJT. Since we were able to gather data on the tech school achievement of the individuals in our sample, we were able to explore some aspects of the relationship between tech school achievement and on-the-job training costs. We could not explore the cost-effectiveness of the current tech school course or the relative merits of alternative types of courses because there was no variation in our sample with respect to tech school training. However, such comparisons are certainly possible within the analytical framework described here and will be undertaken in the course of future Rand research in this area. With currently available data, two questions can be examined: (1) Is tech school achievement significantly related to OJT costs, and (2) Which of the available measures of tech school achievement is most closely associated with OJT costs?

Three measures of tech school achievement were used in our analysis. The first (TSW) is the average on the four written tests given during the tech school course (one following each of the four major sections of the course). The second (TSP) is the average score on performance tests over each of the four sections of the course. The third (TSF), the course grade, is simply an average of the entire eight scores.

In Table 7 which summarizes the results of our analyses using tech school achievement measures, Eq. (9) which contains our basic results from the previous section has again been reproduced for purposes of comparison. Equations (14), (15), and (16) show estimated coefficients and ratios when TSW, TSP and TSF, respectively, are added to the variables in Eq. (9). As these equations show, written test scores and the course grade are poorer predictors of on-the-job productivity than performance test scores--both in terms of the t ratio on the estimated tech school coefficient and the percent of total variation explained (R^2). Since the course grade is an average of written and performance test scores, and since the t ratio on the written test scores is quite low, presumably the association between OJT costs and course score is primarily attributable to performance test achievement. Because all trainees have received the same tech school training, we cannot infer from these results that "hands on" training (where teaching is directly related to relevant equipment) is preferable to classroom instruction. However, these results do indicate that the skills and abilities measured on performance tests

Table 7

TECH SCHOOL RELATIONSHIPS

Equation No.	Variable (t ratio)								
	YRSED	SOUTH	WHITE	EXP	AQE4	TSW	TSP	TSF	R^2
(9)	-669.86 (-2.697)	-173.76 (-.375)	733.57 (1.494)	-9.99 (-.055)	-39.74 (-2.440)				.274
(14)	-664.65 (-2.605)	-142.34 (-.297)	768.06 (1.516)	10.15 (.054)	-33.77 (-1.711)	-21.15 (-.584)			.277
(15)	-595.98 (-2.278)	-324.28 (-.664)	1,338.3 (2.492)	86.74 (.448)	-9.68 (-.498)		-187.57 (-3.577)		.419
(16)	-676.92 (-2.397)	-141.36 (-.299)	1,033.2 (1.817)	59.22 (.285)	-19.77 (-.913)			-104.80 (-2.070)	.321

are much more strongly related to productivity on the job than those measured on written tests, and they suggest that if predicted school achievement is to be used as a specialty assignment criterion in this specialty, predicted achievement on performance tests is superior to predicted course grade.

IV. FUTURE RESEARCH ON THE COST AND RETURNS TO TRAINING

The primary purpose of the pilot study was to determine the feasibility of the cost estimation procedure described here. In that regard the results have been quite encouraging. The problem of measuring OJT costs is important because it may be impossible to determine optimal training policies without such measures. The efficient training of first-term enlisted specialists will almost necessarily entail a combination of formal specialty schooling and informal learning on the job. Further, it is reasonable to expect that the cost of on-the-job training would depend on the length, organization, content, and other characteristics of formal schooling. One must be able, therefore, to measure OJT costs to determine the optimal mix between formal schooling and OJT. Moreover, the most desirable training policy may well differ across types of individuals, and it is important to be able to relate training costs to trainee characteristics as permitted by our methodology.

Rand is beginning a study which builds on our experience in measuring OJT costs to address the problem of determining policies relating to the mix between school training and informal on-the-job training. Since the solution will in general be different for each military specialty, the objective of the research is not to provide specific solutions but to develop management tools to assist training planners in determining the mix between school training and OJT.

As part of this research we will be undertaking a number of case studies of military training in which we will be looking at the total cost of training (net of returns) under different training practices. Three types of variations in training will be examined: variations in the length of training in a given service, variations in the length of training across services if comparable specialties can be found, and variations in training technology either within or across services. The first will primarily involve specialties where some recruits attend military specialty school and others do not. The second will involve variations in the length of training across services. The third will involve comparisons where training may utilize such innovations as peer trainers, and individualized instruction at one training center or in one service in contrast to more conventional training methods elsewhere. We will compare the effectiveness of these different types of training controlling for systematic differences in trainee quality by including trainee attributes in the analysis. Inclusion of trainee attributes will also permit us to examine whether there is a relationship between trainee characteristics and the most effective type of training.

For example, we might find that longer schooling periods are most appropriate for trainees with above average intelligence and/or prior education, while training in a job context is more effective for lower aptitude, less educated trainees who do not respond as well to instruction in a formal setting.

While these studies are an important part of our analysis in this area, they are not, as previously noted, the ultimate objective of the research by any means. Observable variations in training represent only a small portion of potential variations; the method of analysis is both time consuming and expensive and training policies must be continuously evaluated; and training decisions must be integrated with other aspects of military specialty management such as length of commitment, specialty assignment, utilization, and retention policies.

V. EFFICIENCY IN THE MANAGEMENT OF MILITARY MANPOWER

The function of specialized training is to help provide manpower resources required in a military specialty, but other aspects of military manpower policy also affect the quality of manpower in operating units. Assignment and utilization policies determine how trained manpower is used. Procurement policies determine not only the number of recruits entering training but also their qualitative attributes (education, ability, and prior experience). Retention policies determine the average length of time the trained individual will remain in the military. Efficiency in managing the military specialty involves effectively coordinating all the policies and practices which affect the total cost of acquiring manpower resources needed in the specialty.* Efficient management requires that policies in different areas must be coordinated in such a way as to minimize the cost of manning a specialty.

The training practices which turn out to be efficient, as was previously indicated, are those which maximize the net returns to training. Choices made in other policy areas will influence which training practices are efficient. For instance, the amount of training that should be given to first-term personnel depends on both the length of commitment by the individual and the probability of reenlistment, since those two factors have a direct effect on the returns to military training. The longer the individual remains on active duty the longer the period of time in which the military is earning a return on its investment in training. Current practices in the Department of Defense give some indications that these relationships are understood. In the Navy, for example, individuals making a six-year commitment typically receive more training than personnel in the same rating who enlist for only four years. The variable reenlistment bonus program, which the Rand ARPA Manpower Program is also studying, takes training costs into account in choosing specialties for VRB awards. Specialties ranked in the top quartile of all specialties in terms of training costs meet one of the qualifications for the highest VRB payment. Thus, where formal training costs are high, DoD attempts to increase retention by paying a higher bonus to reenlistees. Although these examples are more than isolated instances, there is a continual need to recognize the interdependence of military manpower policies and to coordinate a wide variety of policies in order to achieve real efficiency in managing military manpower.

The fundamental changes in military manpower supply which have occurred as a result of the all-volunteer force (AVF) may mean that

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*For purposes of this discussion, we ignore the possibility of substitutions of capital for labor or other non-manpower policies.

adjustments are necessary in a number of policy areas. The major effect of the AVF has been to increase the relative cost of inexperienced personnel in the military. Not only has first-term pay risen relative to career pay since 1969, but with the loss of the draft the military can no longer hire an unlimited number of personnel at the prevailing rate of military pay. Pay must be increased to attract additional enlistees, and, as in the case of reenlistees, the marginal cost is greater than the rate of pay.

This change in the cost relationship between experienced and inexperienced personnel may make it attractive for the military (1) to seek major increases in retention rates which would reduce the reliance of the services on (now) relatively expensive untrained personnel and (2) to accept enlistees who might have been rejected in the past. This latter move would serve to increase enlistments without a further pay increase. Both of these changes are likely to have major effects on efficient training policies under the AVF. If retention does increase, then the military may find it desirable, as the Navy has, to provide substantially more formal training when the expected years of service increase. In the case of lower standards for enlistment, our pilot study has shown that less educated, less able individuals are more expensive to train. New training policies may be desirable if the type of enlistee who enters under the AVF differs significantly from the enlistee entering the military in previous years.